tions against about 1 per cent for their pupils ; the favorite form for the latter was from whole to part. A further table shows the influence of the original word used, "tree," for example, suggesting "leaves" (whole to part), while "courage" suggested its like or its opposite. By no means the least interesting part of the research, and one contributing greatly to the proper conception of the results, is the appendix of subjective observations by the experimenters and several of their subjects.

(1). *Untersuchung über die Latenzdauer der Muskelzuckung in ihrer Abhängigkeit von verschiedenen Variabeln.* Dr. ROBERT TIGERSTEDT. Archiv für Anat. u. Physiol. (Physiol. Abth.), 1885, p. 111.

(2). *Die Scheinbare Latenzperiode der Erregung bei directer Muskelreizung.* Dr. EMERICH NAGY V. REGÉCZY. Pflüger's Arch., Vol. 43, p. 584.

(3). *On the Normal Duration and Significance of the "Latent Period of Excitation" in Muscle-contraction.* G. F. YEO. Jour. of Phys., Vol. IX, p. 396.

Helmholtz in 1850 discovered that a period of time elapses between the moment of stimulating a muscle and the commencement of the ensuing contraction. He found this latent period to be approximately 0.01″, and thought that submaximal shocks, as well as loading, overloading and fatigue, caused this value to vary. He did not attempt to explain the meaning of this lost time, and even thought it possible that contraction might begin immediately on stimulation. Since 1850 other investigators have variously estimated the latent periods within very wide limits; but after the researches of von Bezold and Bernstein, a duration of 0.01″—0.02″ seems to have been universally accepted as the normal period, coupled generally with the view that this time is consumed by certain molecular changes prerequisite to contraction.

In 1879, however, Gad combated this opinion, and was led by Bernstein's work, which showed the latency of the electric changes of the muscle preceding contraction to be about 0.001″, to regard the latency of the individual muscle elements as of similar amount. He pierced the belly of the muscle with a recording lever, and, upon stimulating the lower end, obtained a curve indicating an initial lengthening of the muscle before contraction began. He considered this as evidence that when the muscle is stimulated, the muscle elements originate a local contraction and stretch their fellows more remote. According to his view, therefore, the latent period is the time required for the contraction to include a number of muscle elements more than sufficient to compensate the initial elongation. Since the whole must be greater than any of its parts, he maintains that the latency of the individual elements must be less than that of the whole muscle.

(1). In *du Bois-Reymond's Archiv* for 1885, Robert Tigerstedt gave the results of his research upon the latent period. As had been conceded before him, he found that temperature was an important condition, and concluded that the latency from 12°—16°.9 C. is 0.006″; from 17°—18°.9, 0.005″; and from 20°—29° C., 0.004.″ Bernstein had discovered that the impulse from nerve to muscle was delayed in the nerve endings 0.0032″. Tigerstedt, who adopts 0.002″ instead of 0.0032″, notes that in direct maximal stimulation of an uncurarized muscle, in consequence of this delay, there are

two waves of excitation—one proceeding from the muscle substance directly, and another from the nerve endings, and these waves may summate. If curare is not administered, the latency is longer and maximal contractions are at times obtained with much weaker shocks; but if the endings are thrown out of action by curare, the latency is not dependent upon the shock. The latency within normal limits is independent of the tension of the muscle.

Taking up the line of thought pursued by Gad, he declares that many muscle elements must be active before a contraction becomes manifest, and that without doubt the latent period of these elements is less than that of the whole muscle. The latent period of the muscle, according to him, is the time taken up by the wave of contraction, which begins at once, or very soon after the stimulation, to traverse a sufficient length of muscle (12 mm.) to render the contraction perceptible.

(2). In his article in *Pflüger's Archiv*, Vol. 43, Regéczy seems to have accepted the work of Gad and Tigerstedt without qualification, and boldly speaks of the "apparent" latent period. He finds that the muscle curve generally rises earlier if the excitation starts from the lower end than if from the upper one, and that the duration of the latency varies inversely as the thickness and length of the muscle. When the stimulation falls in simultaneously at both ends of the muscle, the latency is longer than when the middle of the muscle is stimulated, because more resistance and more stretching are encountered. In short, he believes that all conditions influencing the period begin in affecting the stretching, and were it not for this, no latency of the excitation would exist.

(3). To this view of Gad, Tigerstedt, and Regéczy, Yeo takes exception. He maintains that it not only disagrees with all that we know of contractile tissue, both animal and vegetable, but also that it has not been definitely proved. Concerning the latent period, however, he admits that the old estimate of 0.01″ is certainly too high, and thinks that 0.0065″ is more accurate. In general, his results seem utterly at variance with those of the three investigators just mentioned. In the first place, contrary to Tigerstedt's view, he declares the latency to be prolonged by increase of load; and in regard to stimulation he says, "It would seem that the latency varies with changes of intensity of stimulation, even when the nerve terminals are paralysed [by curare] and the stimulations are maximal." He finds Gad's curves are very easy to get, not only as Gad did, by stimulation of the lower end, but also by stimulating the muscle throughout its whole length, and that with any direction of current; by using the electric signal for marking the beginning of the contraction, he affirms that the elongation occupies the second half of the latent period of the half muscle, and hence cannot, as Gad supposed, be the cause of the latent period. He concludes from his work upon this point, that a preliminary elongation does take place at times, when the latency is recorded by a lever transfixing the belly of the muscle, but that it might be due to the non-recognition of the earliest contracting efforts, while the heavy direct weight quickly indicates increased extensibility of the tissue; or it might be "that the transfixing needle and electrodes cause some polarisation, and consequent slight tonic contraction, which may be inhibited on stimulation." Again, if Tigerstedt's view be right, viz. that the latent period is the time required for the wave of contraction, which starts immediately after stimulation, to travel over a certain dis-

tance before the contraction is able to show itself, then the latency of the part of the muscle where the shock is sent in should be little or nil; yet Yeo obtained nearly the typical latency under such circumstances. The author concludes that "the latency of the individual muscle elements is a theoretical speculation which appears difficult to determine by experimental methods, and which I feel disinclined to investigate. Graphically I think it cannot be shown to be shorter than that observed at the actual point of stimulation—*i. e.* nearly .005″."

What is wanted is plainly more work, and such work as will fill up the gaps in the researches now extant. Thus, to mention some of the more obvious defects, Gad does little more than state his results; Tigerstedt, generally very satisfactory and explicit, fails to give the name of the muscle used by him, although it is known that the degree of regularity of form of the muscle is of considerable importance; and Yeo, while finding fault with Tigerstedt for employing hypermaximal and injurious stimuli, seems possibly himself at times to have made use of submaximal shocks.

It is interesting to compare the various numerical values of the latent period found from time to time by different observers. The excellent table of Yeo is used as a basis for the following:

1850.	Helmholtz,	.01″	1877.	Lautenbach,	.008″
1859.	Harless,	.0187		Brücke,	.007
	Bezold,	.0136		Gad,	.004
	Wundt,	.01	1879.	Sewall,	.01
1862.	Fick,	.007		Richet,	.008
1867.	Place,	.005		Langendorf,	.009
1868.	Marey,	.01		Mendelssohn,	.008
	Klunder and Hensen,	.0085	1883.	Cash and Yeo,	.009
	Lamansky,	.0075		Rosenthal,	.009
1870.	Volkmann,	.01	1885.	Fredericq,	.018
1871.	Valentine,	.021		Tigerstedt,	.005
	Bernstein,	.0188	1888.	Regéczy,	.0033
1874.	Ranvier,	.015		Yeo,	.0065

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Die Theorie der Muskelcontraktion. G. E. MÜLLER. Nachrichten von der Königlichen Gesellschaft der Wissenschaften und der Georg-Augusts-Universität zu Göttingen, No. 7, March, 1889.

As the whole question of the latent period is intimately connected with the obscure problem of muscle contraction, perhaps the elaborate theory of contraction recently formulated by Müller may be of interest here.

This author, discarding the views of Krause, Merkel, and Engelmann, starts out with three fundamental, constituent elements of the muscle fiber, which he designates *disdiaklasten*, *gerüstsubstanz*, and *muskelsaft*. The disdiaklasts (Brücke's term for the doubly refracting particles of the muscle) are here elongated aggregates of such particles or micellae, so arranged that their long axes are parallel to that of the fiber. Running from one end of the fiber to the other there are series of cross columns of these disdiaklasts at the level of the anisotropic bands, the individual disdiaklasts of each column being united laterally with their neighbors by little crosswise rods or threads (*querbälkchen*) forming a network, and longi-